The Impact of Prior Coffee Consumption on the Subsequent Ergogenic Effect of Anhydrous Caffeine

Tom M. McLellan and Doug G. Bell

This study examined whether the prior consumption of coffee (COF) decreased the ergogenic effect of the subsequent ingestion of anhydrous caffeine (CAF). Thirteen subjects performed 6 rides to exhaustion at 80% \( \text{VO}_{2\text{max}} \) 1.5 h after ingesting combinations of COF, decaffeinated coffee (DECOF), CAF, or placebo. The conditions were DECOF + placebo (A), DECOF + CAF (5 mg/kg) (B), COF (1.1 mg/kg caffeine) + CAF (5 mg/kg) (C), COF + CAF (3 mg/kg) (D), COF + CAF (7 mg/kg) (E), and colored water + CAF (5 mg/kg) (F). Times to exhaustion were significantly greater for all trials with CAF versus placebo (trial A). Exercise times (in minutes) were: 21.7 ± 8.1, 29.0 ± 7.4, 27.8 ± 10.8, 25.1 ± 7.9, 26.4 ± 8.0 and 26.8 ± 8.1 for trials A through F, respectively. In conclusion, the prior consumption of COF did not decrease the ergogenic effect of the subsequent ingestion of anhydrous CAF.

Key Words: time to exhaustion, ergogenic, cycling, military

Numerous studies have reported an ergogenic effect following the ingestion of anhydrous caffeine (CAF) either delivered in capsule form or dissolved in warm water (1, 2, 5, 6, 13, 16, 22, 25, 26, 29). In contrast, results are equivocal when the source of CAF is ingested as coffee (COF) (15, 31). Wiles et al. (31) reported a significant improvement in 1.5 km run times after ingesting caffeine in the form of coffee, whereas more recent observations have challenged these findings. Graham et al. (15) showed that running time to exhaustion at 80% \( \text{VO}_{2\text{max}} \) following the ingestion of anhydrous CAF in capsules was improved 31% when compared to placebo and 23% when compared to decaffeinated coffee (DECOF) ingestion. When similar blood concentrations of CAF were achieved following the ingestion of COF or anhydrous CAF dissolved in DECOF performances were not improved, however. The findings by Graham et al. (15) suggest that some other component(s) common to both COF and DECOF alter the adenosine receptor sensitivity to circulating levels of CAF and suppress the ergogenic effect of the drug. Presently, this mechanism of action is speculative and any ingredients in COF and DECOF that silence the ergogenic effect of CAF have not been identified. de Paulis et al. (10) have shown, however, that derivatives of the chlorogenic acids found in coffee beans could interfere with the binding of CAF to the adenosine receptor.
Graham et al. (15) imply that CAF must be ingested in anhydrous form to produce an ergogenic effect. Yet, many individuals who are dietary consumers of the drug obtain their greatest exposure to CAF through regular consumption of COF. Because the duration of the possible inhibitory effects of the derivatives of the chlorogenic acids is not known, these effects could persist for some time following the consumption of COF. If these individuals are athletes interested in using CAF to enhance their performance or military personnel advised to ingest CAF to assist with physical and cognitive function during sustained operations, it is critical to know whether the effects of anhydrous CAF are increased, reduced, or eliminated after drinking a cup of COF. To our knowledge, the effect of a prior cup of COF on the ergogenic effect of anhydrous CAF delivered in capsule form has not been studied.

It was not the intent of the present study to redo the earlier work by Graham et al. (15) and test whether there was an ergogenic effect that followed the consumption of multiple cups of coffee consumed at one time. Rather, having accepted the internal validity of their findings, our concern for this investigation focused on whether the prior consumption of a cup of COF affected the subsequent ergogenic effect of anhydrous CAF delivered in an alternative form. Our expectation was that users of caffeine would typically consume a cup of coffee at various times throughout the day and would not consume large volumes or multiple cups of strong coffee in a very short time period. Our interest was whether this prior consumption of coffee would affect the guidance that could be provided to military commanders, for example, for the expected benefit that would follow the ingestion of a bolus of anhydrous caffeine. Thus, it was the purpose of this study to determine in dietary CAF users whether the prior consumption of a cup of COF influenced the subsequent impact of anhydrous CAF ingestion on exercise performance. It was hypothesized that despite similar blood concentrations of CAF the ergogenic effect that followed anhydrous CAF ingestion would be greatest when it was preceded by a placebo drink rather than by either COF or DECOF.

**Methods**

**Subjects**

Thirteen healthy subjects, nine male and four female, with mean ± standard deviation values for age of 34 ± 8 y, height 176 ± 9 cm, and body mass 75.9 ± 12.9 kg participated in this study. All subjects were physically active and had a cycle ergometer aerobic power (VO$_{2\text{max}}$) of 52 ± 4 mL · kg$^{-1}$ · min$^{-1}$ for the males and 40 ± 3 mL · kg$^{-1}$ · min$^{-1}$ for the females. All subjects were caffeine users who would be classified as moderate to high consumers of the drug (608 ± 446 mg/d) as categorized by their response to a questionnaire on caffeine use administered at the beginning of the study. Caffeine was predominantly ingested in the form of coffee; other caffeine products, however, were also ingested (i.e., tea, cola, and chocolate bars). The subjects were fully informed of the details, discomforts, and risks associated with the experimental protocol, and written informed consent was obtained. The subjects were asked to refrain from heavy exercise and alcohol for 24 h and to refrain from caffeine or products containing caffeine for 12 h before each trial. This study was approved by the human ethics review committee of Defence R&D Canada – Toronto.
Procedures

The subjects visited the laboratory on 9 occasions. During the initial visit, subjects were medically screened and had their VO\(_{2\text{max}}\) determined on an electrically braked cycle ergometer (Ergometrics 800, Sensormedics, Yorba Linda, CA). Male subjects began pedaling at a power output of 75 watts (W) and this was increased 50 W every 4 min until a work rate of 225 W was attained. Thereafter the work rate was increased 50 W every min until exhaustion. Females started at 60 W, with the power output increased by 30 W every 4 min until a work rate of 150 W was attained. Thereafter the workload was increased 30 W every min until exhaustion. Open-circuit spirometry was used to determine oxygen consumption (VO\(_2\)) every 30 s and the highest value obtained was defined as the VO\(_2\). Heart rate (HR) was monitored every min using a transmitter/telemetry unit (Vantage XL Polar System, Port Washington, NY). The relationship between VO\(_2\) and power output was derived from this test and from that relationship the power outputs equivalent to approximately 50% and 80% VO\(_{2\text{max}}\) were used during the subsequent trials on the same ergometer.

During the next 8 visits the subjects performed the exhaustion ride (ER) at the same time of day. The majority of the ERs were performed on a weekly basis but occasionally up to 3 wk intervened between test sessions. The ER consisted of 2 phases. The first phase involved 5 min of cycling at approximately 50% VO\(_{2\text{max}}\) with a pedal frequency that was self-selected between 60 and 100 rev/min. Immediately thereafter, the second phase began, which consisted of a ride to exhaustion at approximately 80% VO\(_{2\text{max}}\) at the same pedaling frequency. Once the pedal frequency dropped below 50 rev/min the session was stopped.

Visits 2 and 3 were familiarizations to the treatment procedures. On arriving for the first familiarization visit, a 5 mL blood sample was immediately taken via a venipuncture. The sample was immediately spun and the plasma was frozen and later used to give background levels of caffeine after having abstained for 12 h. After the blood sample, subjects were given a volume of Royal Blend® Swiss water filtered DECOF (approximately 150 to 250 mL) in a cup covered with an opaque lid followed 30 min later by placebo capsules filled with Metamucil®, a dietary fiber, which was ingested with 100 mL of water. One hour later the subject performed the ER. During the ER, open-circuit spirometry was used to determine VO\(_2\) during the first 5 min at 50% VO\(_{2\text{max}}\) during the first 5 min and after 15 min at 80% VO\(_{2\text{max}}\). After each respiratory gas analysis the subject ingested 100 mL of water to alleviate the dryness caused by the mouthpiece. A whole-body rating of perceived exertion (RPE) using the Borg scale (4) and HR, were recorded every 5 min. HR was monitored via a telemetry system (wrist watch) (Vantage XL, Polar Electro, Port Washington, NY). Subjects performed the ER dressed in their normal cycling gear. The ER was conducted in a room that was controlled at 20 to 22 °C.

The second familiarization session was exactly like the first session except that the subjects were given a cup of COF that contained slightly more than 1 mg of CAF per kilogram of body weight. Five hundred mL of water was drip filtered over 15 g of COF (Royal Blend®) in an automatic COF maker to produce a brew containing 0.5 mg of CAF/mL. The total volume of COF ingested varied between 150 to 250 mL for our subjects. This was followed 30 min later by capsules filled with CAF in an amount equivalent to 5 mg/kg body weight.
The procedures for the treatment sessions were identical to the familiarization sessions except that the blood sample was taken just prior to the ER after ingestion of their drink and capsules. The combinations for the treatment trials were as follows: DECOF + placebo capsules, labeled as treatment A; DECOF + CAF capsules (5 mg/kg CAF), labeled as B; COF (1.1 mg/kg CAF) + CAF capsules (5 mg/kg CAF), labeled as C; COF + CAF capsules (3 mg/kg CAF), labeled as D; COF + CAF capsules (7 mg/kg CAF), labeled as E; and, an equivalent volume of drip filtered water with brown coloring + CAF capsules (5 mg/kg CAF), labeled as F. Each subject acted as their own control and underwent all trials. The order of these trials was double blind and randomized. After the completion of each trial, subjects were asked to identify the type of drink and pill that they believed they received.

**Measurements**

For all trials, the plasma and coffee were assayed for caffeine concentration using gas chromatograph-mass spectrometry electron impact single ion monitoring (model MSD 5970a, Hewlett-Packard, Palo Alto, CA).

**Statistics**

A repeated measures analysis of variance design employing computer software (Statistica V6.1, StatSoft Inc., Tulsa, OK) was used to compare the changes in the dependent variables across treatments and time. When the ANOVA yielded a significant $F$-ratio, a Newman-Keuls post hoc test was done. Statistical significance was accepted at the $P \leq 0.05$ level.

**Results**

**Caffeine Concentration**

Figure 1 shows the concentration of CAF in the plasma on arrival for the familiarization trials (F1, F2) and just prior to the ER, after COF/CAF ingestion for the 6 treatment trials, A-F. A small but residual amount of CAF was evident in the plasma during F1 and F2 and during the placebo trial (trial A) with DECOF after abstaining from CAF for approximately 12 to 14 h. These residual amounts of CAF were similar among these trials. When the drug was added by either drinking COF or ingesting anhydrous CAF in capsules, the plasma concentrations increased in proportion to the total dose of CAF administered. Plasma CAF concentrations were significantly different among the trials that involved both COF and CAF ingestion (trials C, D, and E) and were not different between the 2 trials that involved only the ingestion of CAF capsules (trials B and F). Values also were not different, however, between these latter trials and trial D and between trials F and C. The concentration of CAF in the drip-filtered brews averaged 0.02 ± 0.01 mg/mL and 0.48 ± 0.05 mg/mL for the DECOF and COF trials, respectively.

**Time to Exhaustion**

Compared with the placebo trial (condition A), exercise time to exhaustion was increased significantly following CAF ingestion regardless of whether COF or
DECOF preceded the anhydrous CAF ingestion and regardless of whether the dose of the drug in anhydrous form varied from 3 to 7 mg/kg (Figure 2). Although the individual response was quite variable, exercise time following CAF ingestion was $27.0 \pm 8.4$ min compared with the $21.7 \pm 8.1$ min recorded during the placebo trial, representing an approximate increase that averaged 24%.

![Graph](image)

**Figure 1**—Caffeine concentration in the blood just before capsule ingestion in the familiarization trials (F1 and F2) and just before the commencement of the exhaustion ride for the treatment trials (A-F).

*Note.* F1, familiarization 1; F2, familiarization 2; A, DECOF + Placebo; B, DECOF + CAF (5 mg/kg); C, COF (1.1 mg/kg caffeine) + CAF (5 mg/kg); D, COF + CAF (3 mg/kg); E, COF + CAF (7 mg/kg); F, colored water + CAF (5 mg/kg). Solid line indicates similar means. See the text for a description of statistical differences among trials B to F.

**Figure 2**—Time to exhaustion at 80% $\text{VO}_{2\text{max}}$ in caffeine users following the consumption of decaffeinated coffee (DECOF), regular coffee (COF), or colored water together with varying doses of anhydrous caffeine (CAF).

*Note.* *Significantly different from all other treatments. A, DECOF + Placebo; B, DECOF + CAF (5 mg/kg); C, COF (1.1 mg/kg caffeine) + CAF (5 mg/kg); D, COF + CAF (3 mg/kg); E, COF + CAF (7 mg/kg); F, colored water + CAF (5 mg/kg).
Ergogenic Effect of Anhydrous Caffeine

Oxygen Consumption

CAF ingestion from COF or anhydrous CAF capsules did not affect VO$_2$ during either the warm-up at 50% VO$_{2\text{max}}$ or during the ER at 80% VO$_2$ (Table 1). There was, however, an effect of time during the ER. At 5 min VO$_2$ was similar among the trials and ranged from 2.98 to 3.03 L/min or approximately 81% VO$_{2\text{max}}$. By 15 min VO$_2$ had significantly increased and ranged from 3.17 to 3.30 L/min or about 90% VO$_{2\text{max}}$.

Heart Rate

As shown in Table 2, CAF ingestion from COF or anhydrous CAF capsules did not affect HR during the warm-up or ER. There was, however, a significant increase over time with values rising significantly from 159 ± 9 beats/min after 5 min to 167 ± 12 and 170 ± 13 beats/min after 10 and 15 min of exercise, respectively, during the ER. Values recorded after 10 and 15 min of exercise were not significantly different.

Rating of Perceived Exertion

RPE also was not affected by the CAF ingestion from COF or anhydrous CAF capsules during the warm-up at 50% VO$_{2\text{max}}$ (Table 3). During the ER at 80% VO$_{2\text{max}}$, there were main effects of both treatment and time, however. The RPE values averaged throughout trial E, which had the largest combined dose of CAF, was significantly lower (13.8 ± 1.3) than trial A (14.6 ± 1.6) that represented the placebo session. No other differences were observed among the trials for this main effect of treatment. RPE also increased significantly at each point of measurement with values being 12.4 ± 1.4, 14.3 ± 1.2, and 16.0 ± 1.0 after 5, 10, and 15 min of exercise at 80% VO$_{2\text{max}}$, respectively.

Identification of Treatment

Subjects correctly identified the ingestion of CAF or placebo pills from a low of 6 of 13 cases in trials C and D to a high of 10 of 13 cases in trial A. Only 1 subject

Table 1  Oxygen Consumption (VO$_2$, L/min) During Exercise after Decaffeinated Coffee (DECOF), Coffee (COF), Anhydrous Caffeine (CAF), or Placebo (Pla) Ingestion

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DECOF+</td>
<td>DECOF+</td>
<td>COF+</td>
<td>COF+</td>
<td>COF+</td>
<td>Colored</td>
</tr>
<tr>
<td>Pla</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Water+</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CAF5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 min</td>
<td>1.70 ± 0.58</td>
<td>1.73 ± 0.53</td>
<td>1.77 ± 0.54</td>
<td>1.74 ± 0.57</td>
<td>1.79 ± 0.53</td>
<td>1.74 ± 0.56</td>
</tr>
<tr>
<td>5 min</td>
<td>2.98 ± 0.99</td>
<td>2.99 ± 0.97</td>
<td>3.02 ± 0.98</td>
<td>2.99 ± 0.97</td>
<td>3.03 ± 0.95</td>
<td>2.99 ± 0.94</td>
</tr>
<tr>
<td>15 min</td>
<td>3.17 ± 0.99</td>
<td>3.22 ± 0.99</td>
<td>3.23 ± 0.99</td>
<td>3.22 ± 0.99</td>
<td>3.31 ± 0.97</td>
<td>3.20 ± 0.99</td>
</tr>
</tbody>
</table>

Note. Values are mean ± standard deviation. *There was a main effect of time indicating that VO$_2$ increased significantly from 5 to 15 min during the performance ride to exhaustion at 80% VO$_{2\text{max}}$. CAF5, 5 mg/kg caffeine; CAF3, 3 mg/kg caffeine; CAF7, 7 mg/kg caffeine; COF, 1.1 mg/kg caffeine.
Table 2  Heart Rate (beats/min) During Exercise after Decaffeinated Coffee (DECOF), Coffee (COF), Anhydrous Caffeine (CAF), or Placebo (Pla) Ingestion

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DECOF+ Pla</td>
<td>DECOF+ CAF5</td>
<td>COF+ CAF5</td>
<td>COF+ CAF3</td>
<td>COF+ CAF7</td>
<td>Colored Water+</td>
</tr>
<tr>
<td>5 min 50%</td>
<td>118 ± 13</td>
<td>115 ± 9</td>
<td>112 ± 10</td>
<td>117 ± 10</td>
<td>111 ± 5</td>
<td>111 ± 9</td>
</tr>
<tr>
<td>5 min 80%</td>
<td>160 ± 10</td>
<td>159 ± 10</td>
<td>157 ± 9</td>
<td>161 ± 8</td>
<td>159 ± 8</td>
<td>159 ± 10</td>
</tr>
<tr>
<td>10 min 80%</td>
<td>168 ± 14</td>
<td>167 ± 13</td>
<td>166 ± 12</td>
<td>169 ± 10</td>
<td>168 ± 12</td>
<td>167 ± 13</td>
</tr>
<tr>
<td>15 min 80%</td>
<td>169 ± 15</td>
<td>170 ± 14</td>
<td>170 ± 12</td>
<td>171 ± 12</td>
<td>172 ± 11</td>
<td>171 ± 13</td>
</tr>
</tbody>
</table>

Note. Values are mean ± standard deviation. *There was a main effect of time indicating that heart rates (beats/min) recorded after 10 and 15 min of exercise were significantly greater than the 5-min value during the ride to exhaustion at 80% VO$_{2\text{max}}$. CAF5, 5 mg/kg caffeine; CAF3, 3 mg/kg caffeine; CAF7, 7 mg/kg caffeine; COF, 1.1 mg/kg caffeine.

Table 3  Rating of Perceived Exertion (RPE) During Exercise after Decaffeinated Coffee (DECOF), Coffee (COF), Anhydrous Caffeine (CAF), or Placebo (Pla) Ingestion

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DECOF+ Pla</td>
<td>DECOF+ CAF5</td>
<td>COF+ CAF5</td>
<td>COF+ CAF3</td>
<td>COF+ CAF7</td>
<td>Colored Water+</td>
</tr>
<tr>
<td>5 min 50%</td>
<td>8.0 ± 1.2</td>
<td>8.3 ± 1.3</td>
<td>8.5 ± 1.3</td>
<td>8.0 ± 1.1</td>
<td>8.0 ± 1.2</td>
<td>8.2 ± 1.3</td>
</tr>
<tr>
<td>5 min 80%</td>
<td>12.9 ± 1.4</td>
<td>12.5 ± 1.3</td>
<td>12.4 ± 2.2</td>
<td>12.5 ± 1.2</td>
<td>12.1 ± 1.8*</td>
<td>12.0 ± 1.5</td>
</tr>
<tr>
<td>10 min 80%</td>
<td>14.6 ± 1.4</td>
<td>14.1 ± 1.2</td>
<td>14.5 ± 1.4</td>
<td>14.4 ± 1.1</td>
<td>14.0 ± 1.6*</td>
<td>14.1 ± 1.2</td>
</tr>
<tr>
<td>15 min 80%</td>
<td>16.4 ± 1.1</td>
<td>15.6 ± 1.3</td>
<td>16.4 ± 1.1</td>
<td>15.9 ± 1.4</td>
<td>15.4 ± 1.5*</td>
<td>16.1 ± 1.3</td>
</tr>
</tbody>
</table>

Note. Values are mean ± standard deviation. *There was a main effect of time indicating that RPE increased significantly at each point of measurement during the ride to exhaustion at 80% VO$_{2\text{max}}$. *There was a main effect of treatment where the values averaged throughout trial E were significantly lower than trial A. CAF5, 5 mg/kg caffeine; CAF3, 3 mg/kg caffeine; CAF7, 7 mg/kg caffeine; COF, 1.1 mg/kg caffeine.

correctly identified the ingestion of CAF or placebo pill for all trials. The identification of COF or DECOF drink appeared more random with successful identification averaging between 5 and 8 of 13 cases. No subject correctly identified the COF or DECOF drink for all trials. Ten of 13 subjects successfully identified the placebo drink in trial F and 7 of 13 subjects identified correctly both the drink and pill combination for this trial. For the other trials, however, the correct identification of both the drink consumed and pill ingested ranged from a low of 2 of 13 cases for trials A and B to a high of 5 of 13 cases for trial E.
**Discussion**

The focus of the present study was to examine whether the prior consumption of a cup of COF affected the ergogenic effect of the subsequent ingestion of anhydrous CAF. The findings presented by Graham et al. (15) implied that users of CAF should not expect the consumption of COF to be ergogenic. In fact, this previous work (15) suggested that the other ingredients present in COF or DECOF might be antagonistic to the potential ergogenic effect of anhydrous CAF ingested in other forms. Nevertheless, one of the primary avenues of access to CAF, for users of the drug, is through the ingestion of COF. Thus, for athletes who might be considering the use of the anhydrous CAF to enhance their performance or in occupational settings such as the military where personnel might be advised to ingest CAF during periods of sleep deprivation, it is critical to know whether the ergogenic effect of the drug would be altered by the prior consumption of COF. The findings from the present study revealed that the consumption of 1 cup of COF does not impact on the subsequent ergogenic effect of anhydrous CAF.

It was not the intent of the present study to challenge the earlier findings reported by Graham et al. (15). We assumed that an ergogenic effect would not be observed if a 5 mg/kg dose of CAF was delivered through the consumption of 2 or 3 cups of strong COF. Nevertheless, the reader should be aware that Graham’s findings are not consistent with earlier reports (8, 31). It is also noteworthy that mental performance in rested or sleep-deprived individuals is improved following CAF ingestion regardless of whether the drug is consumed as COF (28), dissolved in DECOF (23), or administered in capsule (20) or gum form (18). The observations from the present study suggest that additional studies could be warranted to clarify under what conditions the other ingredients in COF or DECOF antagonize the ergogenic effect of CAF.

Conceivably, the amount of chlorogenic acid derivatives found in coffee beans and their potential interference with the binding of CAF to the adenosine receptor (10) might differ from one brand of COF to another. Without additional testing, however, this is purely speculative at this point. Intestinal absorption rates and times to peak plasma concentration are similar for CAF delivered in capsules, as COF, in soft drinks, or in chocolate (3, 21, 24). Thus, whether CAF was dissolved in DECOF, as it was by Graham et al. (15), or administered in capsules 30 min later, as it was in the present study, should not account for the disparate findings. It is also possible that the clearance rates for CAF and other ingredients in COF or DECOF that might inhibit the actions of CAF could be quite different. de Paulis et al. (10) report an elimination half-life of 14 min in mouse brain and plasma for a synthetic chlorogenic acid, whereas the half-life of CAF in human plasma is several hours (3, 14, 27). Because the ergogenic effect of CAF has been reported to last for several hours for users of the drug (1), it is conceivable that the inhibitory actions of other ingredients that could be present in COF are more prevalent earlier following the consumption of the beverage, whereas the ergogenic effect of the drug could become evident much later. In the present study and that by Graham et al. (15), however, the exercise tests were performed at similar times (60 to 75 min) following the ingestion of COF or CAF dissolved in DECOF or consumed in capsule form. Finally, differences in subject characteristics with respect to age,
fitness level, and daily CAF consumption might impact on the ergogenic effect of the drug and make comparisons among studies more difficult (1).

The present data suggest that the ergogenic effect of CAF is dependent on a threshold concentration being present in the blood. Although the ergogenic effect tended to follow an inverted U-shaped relationship with the improvement in performance being less at low and high concentrations of the drug, the improvement in exercise times to exhaustion was not statistically different among the trials where blood concentrations ranged from 35 to 65 μmol/L. There is not a uniform consensus as to whether the ergogenic effect of CAF follows a dose-response relationship (6, 16, 25). Part of this discrepancy could reflect the varied dietary CAF habits of subjects in these studies and differences in sensitivity to CAF between users and nonusers (1, 16, 17). Further, the impact of prior exercise or warm-up activity within the experimental protocol or the delivery of caffeine during exercise could increase one’s sensitivity to CAF and lower the blood concentration of the drug required to exert an ergogenic effect (2, 9, 19). Typically, the amount of CAF required to produce an ergogenic response when consumed prior to exercise has ranged from 3 to 9 mg/kg with users of the drug more likely to get a better response with the higher dose (1, 16, 17). The amount of CAF consumed in the present study from the capsules and COF ranged from 4 to 8 mg/kg.

It was interesting to note that RPE was reduced only for the exercise trial that followed the highest level of CAF ingestion (trial E). The increase in performance, however, was no different than the other CAF trials that were not associated with lower RPE levels compared with the placebo session. Thus a change in performance during all of the caffeine trials was not associated with a consistent change in the perception of effort. Other studies that have found a change in RPE after CAF ingestion (1, 7, 8, 11, 12, 22, 30, 31) used only 1 dose of CAF. The exception is the study by Falk (12) that used a re-dosing strategy. These previous findings together with the present data suggest that there is a dissociation between performance and perceived effort in CAF users that could warrant further study.

In conclusion, the present study found that the ergogenic effect of CAF was not affected by the prior consumption of 1 cup of COF. For users of the drug, the current findings reveal that the ingestion of 5 mg/kg anhydrous CAF will still increase performance approximately 25% following COF consumption.

Acknowledgments

The authors are grateful to Ingrid Smith and Luda Yarin who spent many hours providing technical assistance during the trials. Also we wish to thank Gary Seabrook for analyzing the blood and coffee samples for caffeine content. Further we would like to acknowledge Bill Phillips of Bulk Pharmaceutical Incorporated for providing the caffeine.

References